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TECHNICAL TRANSLATION

F-17

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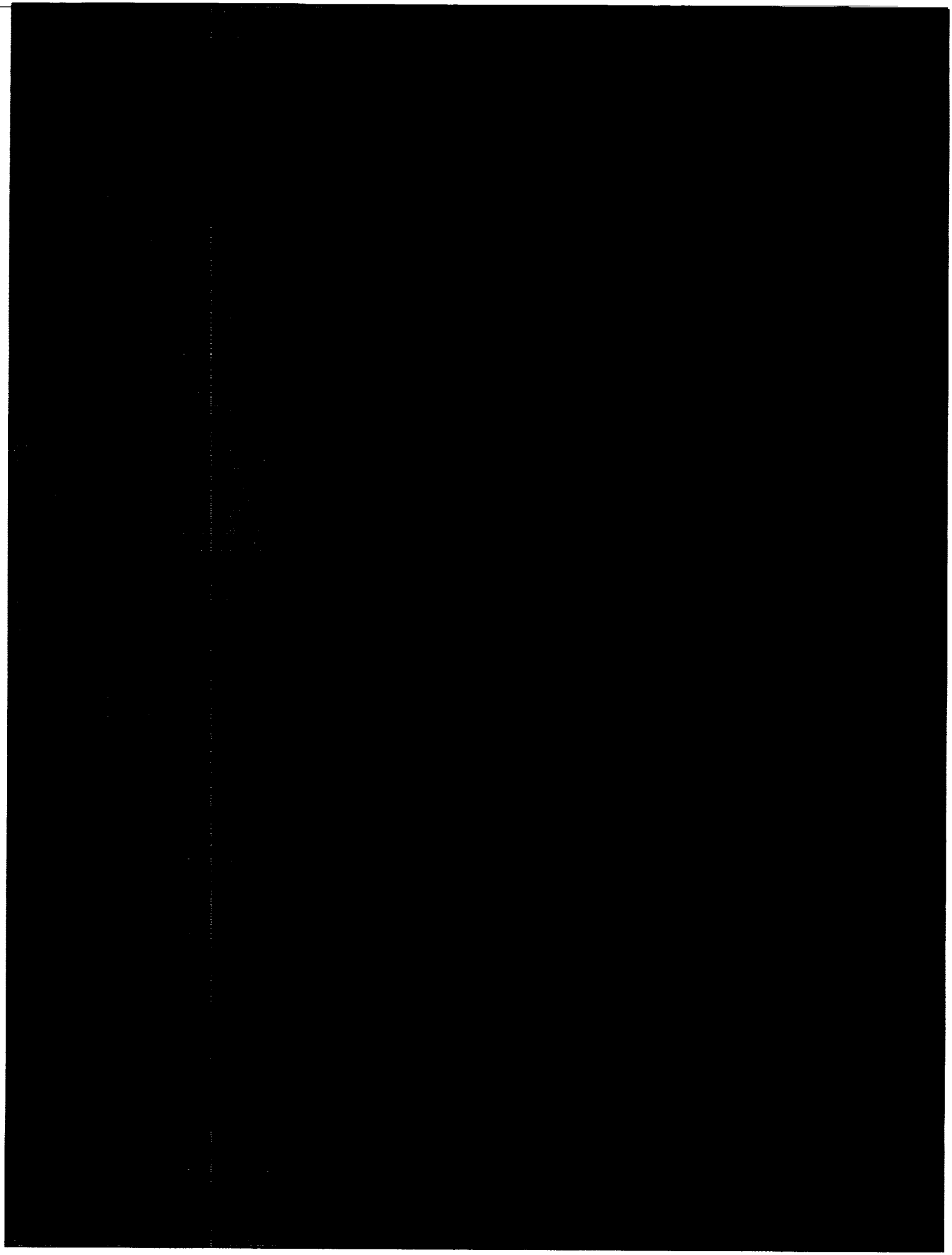
By Jean Rebont, Jacques Valensi,
and Jean Soulez-Larivière

Translation of "Étude en soufflerie de la réponse de la portance d'un rotor à une augmentation de pas général, dans le cas du vol vertical de descente à un régime voisin de l'autorotation."
Comptes Rendus, t. 247, no. 10,
Sept. 8, 1958.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON
April 1960



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WIND-TUNNEL STUDY OF THE RESPONSE IN LIFT OF A ROTOR TO AN INCREASE IN COLLECTIVE PITCH IN THE CASE OF VERTICAL FLIGHT NEAR THE AUTOROTATIVE REGIME*

By Jean Rebont, Jacques Valensi,
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SUMMARY

It has been shown by the calculations of a preceding note that the effect on the lift of a rotor due to an increase in the effective collective pitch, while in the course of steady descending vertical flight near the autorotative regime, depends essentially upon the speed of the pitch change. Experiment confirms the result.

DISCUSSION

It has been shown by the calculation of a preceding Note[1] that the response of the lift of a rotor to an increase in collective pitch presents different behaviors in the case of vertical flight near autorotation, according as the time that is required to change the pitch corresponds to a fraction of a turn or to a more or less large number of turns. Since the utility of the elementary theory rests upon a certain number of simplifying assumptions,[2] it was proper to verify the accuracy of the result by an experiment.

For this, a setup was feasible in the low-speed wind tunnel of the Institute of Fluid Mechanics in Marsielles, involving a rotor behind a helicopter supported in the airstream by a horizontal tube.

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*"Étude en soufflerie de la réponse de la portance d'un rotor à une augmentation de pas général, dans le cas du vol vertical de descente à un régime voisin de l'autorotation." Comptes Rendus, t. 247, no. 10, Sept. 8, 1958, pp. 778-780.

**Institute of Fluid Mechanics of the University of Aix-Marseille.

[1]Comptes Rendus, t. 247, no. 9, Sept. 1, 1958, p. 738. (Now available as NASA TT F-18.)

[2]In particular, the effect of the flapping of the blades on the lift has been assumed negligible.

The rotor had the following characteristics: a diameter of 2 meters and two rectangular, untwisted blades whose chord corresponded to a rotor solidity of 0.085. The retention of the blades at the hub involved the usual articulation, thus allowing flapping. The rotor was turned by a shaft borne by two bearings at the ends of the rotor support tube. The incidence of the plane of the rotor was controlled by rotation of the tube, whereas, the collective pitch was controlled by an intermediate revolving cam which ensured that the collective pitch would follow a law of variation of the form $\theta = A\left[1 - e^{-(t/\alpha)}\right]$ with α and A adjustable. (See footnote 1.)

The diameter of the support tube was chosen to be large and its thickness small, such that the aerodynamic forces acting upon the rotor would induce upon the tube a strong bending moment which is measurable with the aid of extension gages fixed to the external surface in a suitable manner.[3] 4 5 4

The blade flapping and the collective pitch were detected by variable reluctance goniometers. The signals from the bridges of the force gages and the angle meters were transmitted to and recorded in a moving magnet oscillograph which contained a time reference as well as a device for recording the turns of the rotor.

Three records were extracted from the numerous cases studied, and these are reproduced in figures 1, 2, and 3, which correspond to the following test conditions: rotor incidence, 90° (vertical flight);

$$\xi_0 = \lambda_i + \frac{\lambda}{2}\frac{K_2}{K_1} + \frac{1}{2b}\frac{1}{K_1} = 0.025;$$

amplitude of pitch change, $A = 0.158$ radian; α/τ equal to 0.33 for figure 1, 2.1 for figure 2, and 5.5 for figure 3; τ equal to 0.038. The tip speed of the blades was maintained at 180 meters per second and the speed of the wind tunnel at 7.2 meters per second ($\lambda = -0.04$).

It may be seen that the lift response shows all the characteristics predicted by the theory. In particular, figure 2 shows the existence of a lift minimum after 9 rotor revolutions, whereas the lift attains its ultimate value after 15 more revolutions. A notable flapping of the blades may be observed in figures 1 and 2, the amplitude being 2°10' and 1°32', respectively. This flapping was accompanied by intense noise which, however, did not appear to have any influence on the overall lift. It should be noted, however, that in each test the pitch increase was maintained just long enough to permit recording the data, thus much variation in the tunnel speed and in the working conditions of the rotor was

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[3]The setup of the gages as well as the measurements were carried out by M. R. Guillaume.

avoided. The choice of the time scale for the three figures was dictated by the values of α.

Preliminary observations with smoke showed the formation of a strong vortex-ring wake during the course of the pitch change for tests corresponding to figure 2. This wake explains the anomalies observed in the lift response and justifies the introduction of a complementary term as a function of the virtual mass into the expression for the lift. (See footnote 1.)

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Translated by Harry H. Heyson,
National Aeronautics and Space Administation

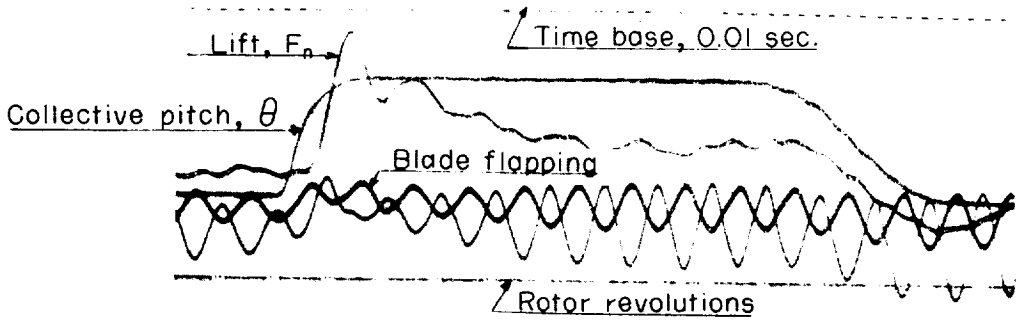

Figure 1

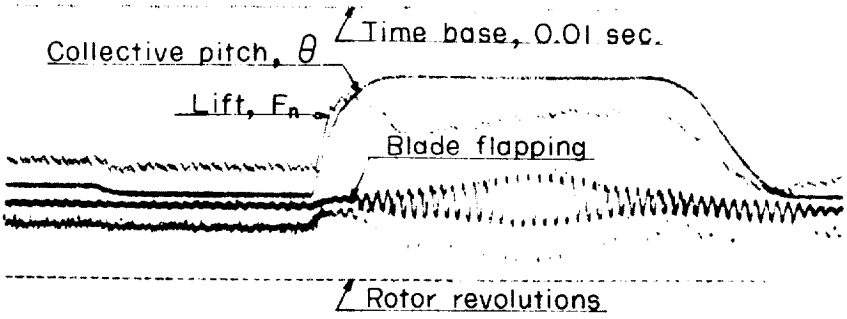

Figure 2

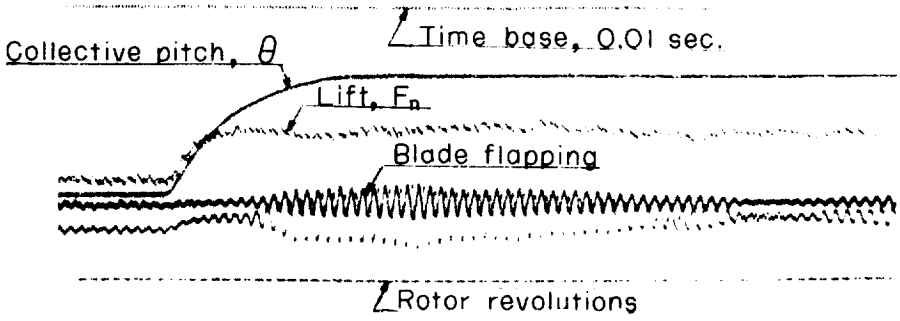

Figure 3

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It has been shown by the calculations of a preceding note that the effect on the lift of a rotor due to an increase in the effective collective pitch, while in the course of steady descending vertical flight near the autorotative regime, depends essentially upon the (over)

Copies obtainable from NASA, Washington

1. Wings, Rotating - Experimental Studies (1.6.2)
2. Rotating-Wing Aircraft (1.7.3)
3. Control (1.8.2)

I. Rebont, Jean
II. Valensi, Jacques
III. Soulez-Larivière, Jean
IV. NASA TT F-17
V. Academi des Sciences, Comptes Rendus, v. 247, no. 10, Sept. 8, 1958, p. 778-780 (France)

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